LESSON 14
POST INSTALLATION AND INTEGRITY TESTING

DRILLED SHAFT FOUNDATION INSPECTION

DECEMBER 2002

LESSON 14
POST INSTALLATION
NOTES

LESSON 14
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NOTES

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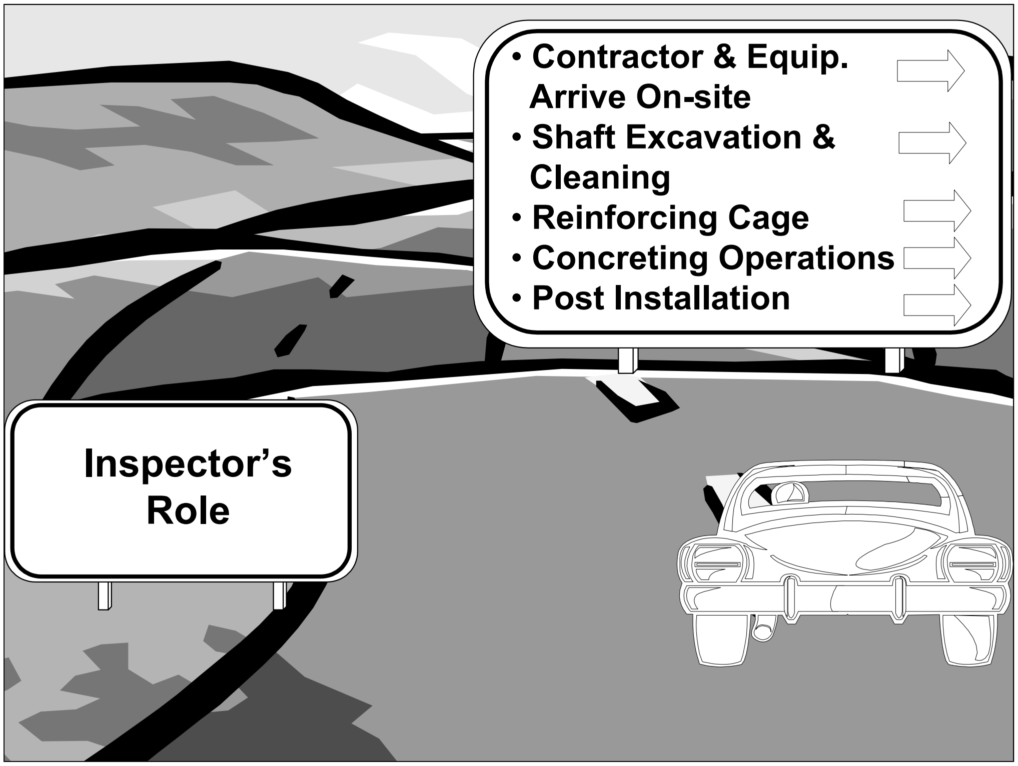
POST INSTALLATION
&
INTEGRITY TESTING

14-4


• Contractor & Equip. Arrive On-site
• Shaft Excavation & Cleaning
• Reinforcing Cage
• Concreting Operations
• Post Installation
Inspector's Role

LEARNING OBJECTIVES

- Describe how to verify Checklist Questions 56-61
- Identify and describe various Integrity and Load Tests
- Explain how to assess and verify the Contractor’s compliance with specifications for casing removal, elevation requirements and construction tolerances
- Describe the Drilled Shaft Pay Items

14-6

POST INSTALLATION TESTS

To determine if the shaft, as constructed, will carry the loads designed for.

LOAD TESTS

To evaluate the soundness or "integrity" of the constructed shaft.

INTEGRITY TESTS

14-7

LOAD TESTS

Typically there are three types of Load tests conducted on drilled shafts:

- **Axial (downward) ASTM D 1143**
- **Lateral (sideways) ASTM D 3966**
- **Uplift (upwards) ASTM 3689**

14-8

AXIAL LOAD TESTS

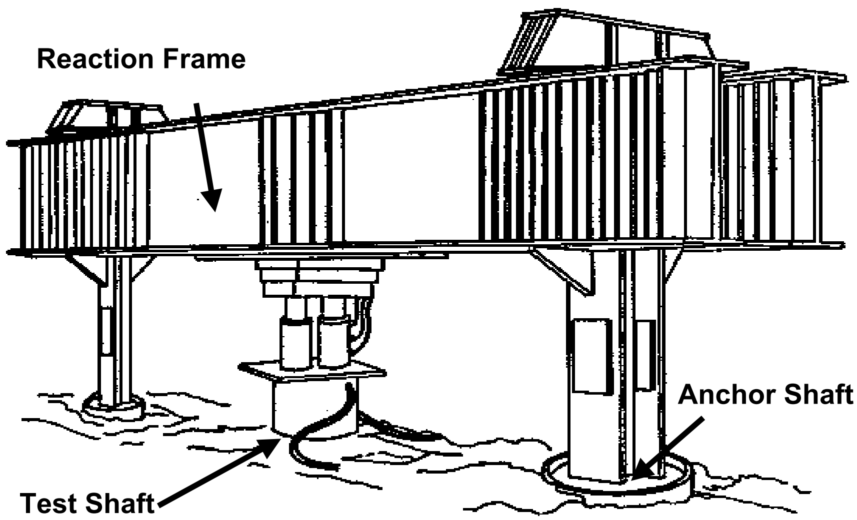
- Conventional Methods (Reaction Frame and Reaction Shafts)
- Osterberg Load Cell(s)
- Statnamic Loading Device
- Others

14-9

The general methods of applying loads in lateral load tests are similar to those for axial load tests. We will briefly review two loading setups in the next two slides.

The issue can be raised here concerning when the load test should be conducted. Ask the participants what they would do. Many agencies allow the load tests to be conducted as soon as the concrete cylinder breaks come up to the agency's minimum 28-day strength. Contractors often accelerate the time by using cement-rich or high-early strength concrete mixes. It is possible that such concrete mixes can affect interface roughness (e. g., develop an interaction with residual polymer slurries), affect transfer of water into clay soils or rock along the interface, etc. It is probably best to use a standard concrete mix that is perhaps slightly rich and test at a period of perhaps 14 days after casting, so that the concrete-geomaterial interface will behave in the load test in a manner similar to the way it will perform in service.

Conventional Methods (Reaction Frame and Reaction Shafts)

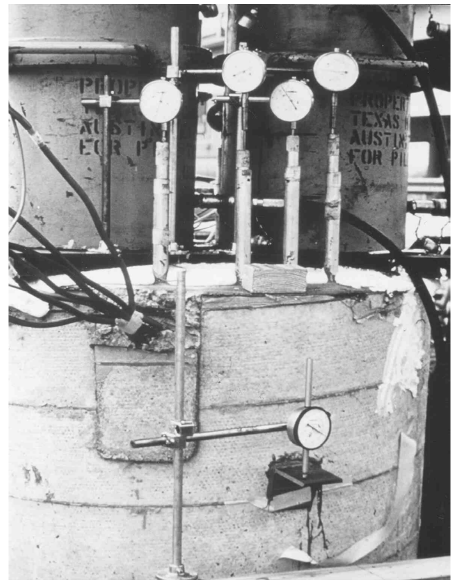


14-10

In a conventional test we install reaction (anchor) shafts on either side of the test shaft (two or four can be used). The reaction shafts should each have approximately the same capacity in uplift as the test shaft has in compression (if two are used), to assure a factor of safety of about two to preclude anchor shaft failure. Again, the anchor shafts should normally be constructed first. Hydraulic jacks are placed on top of the test shaft, usually on a steel plate that is carefully leveled. Electronic load cells are also frequently placed above or below the jacks in order to obtain an accurate measure of the load. A reaction frame spans the anchor shafts, as shown. Potential disadvantages of this method are that it is relatively expensive compared to the other methods discussed (perhaps twice as expensive, excluding the cost of the test shaft) and the capacity is limited because of the use of the reaction frame.

The conventional method can also be used to conduct uplift, or “pullout,” tests.

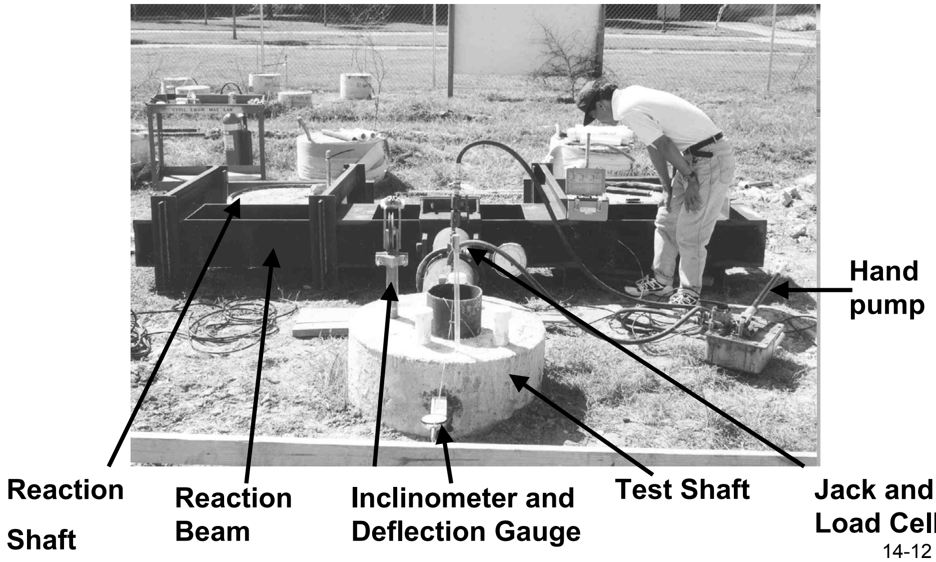
Conventional Methods
(Axial)



These are some photos of the set-up for axial load tests on drilled shafts. On the left is a jack with a pressure gauge calibrated to load (dark gray object), an electronic load cell (silver object), and settlement gauges, in this case mechanical dial gauges. LVDT's or DCVT's can be used in place of dial gauges conveniently if a computer at the field site acquires data. Four settlement gauges are used, one at each corner of a thick steel loading plate affixed to the head of the drilled shaft. Reference beams that are supported on the ground at points at least 10 feet (3 m), clear, from the test and reaction shafts support the settlement gauges. These steel reference beams are shaded from the sun by means of a tarpaulin in order to minimize thermal movements in the reference beams. Two independent means, the electronic load cell and the jack pressure, read the load on the jack. A second, independent method for reading settlement is also a good idea in case the zero is lost on the settlement gauges (very large settlements beyond the range of the settlement gauges, blunder by field crew in hitting reference beams, etc.) This is often accomplished by making optical level readings on a scale affixed to the shaft head. Some mention of desired accuracy in the load and settlement readings might be inserted here.

On the right we see the tops of several telltales. These are unstrained rods that are anchored at various depths within the test shaft. Differences in compression between the top of the shaft and the anchor points are read by the gauges (0.0001 inch dial gauges in this photo). These differences are converted into axial strains and then to stresses and finally to load in order to measure the distribution of load along the shaft. The keys to good telltale readings are rods that do not bind inside their sheaths and accurate estimates of concrete modulus (to convert strain to stress).

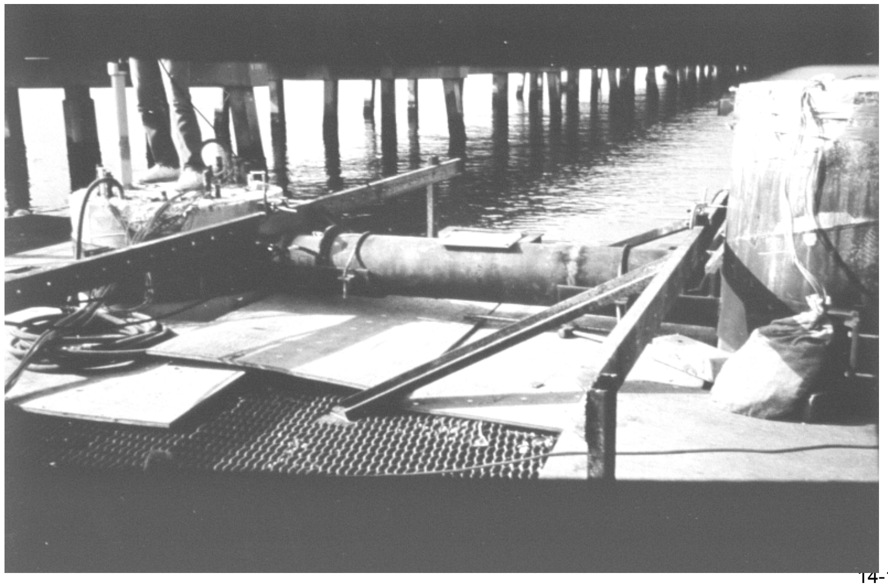
Conventional Methods
(Lateral)



14-12

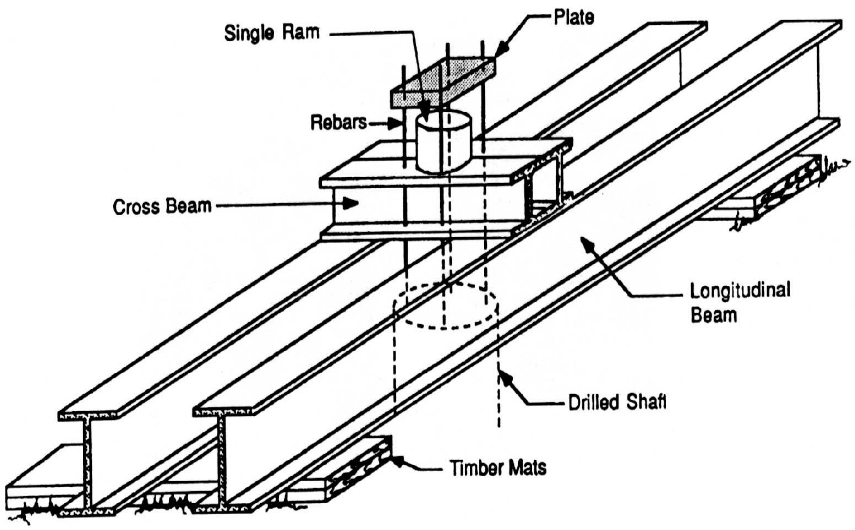
This is a photo of a typical, simple arrangement for loading a drilled shaft laterally. Two companion shafts are used to support the load from the reaction beam. The test shaft is pushed away from the reaction shafts, not pulled toward them (which might produce excessive stress overlaps in the soil). The load is applied as a shear at the ground level and is measured with an electronic load cell. Both the lateral deflections at the level of the applied load and the slope of the shaft (at the head and along the shaft) are measured.

Conventional Methods (Lateral)



14-13

Uplift Test

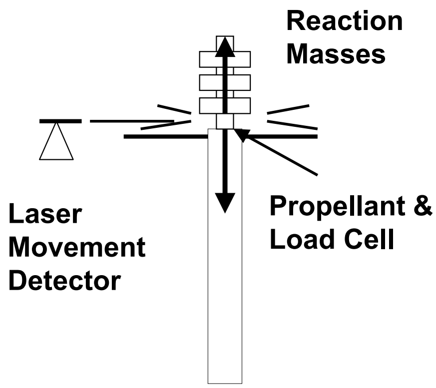


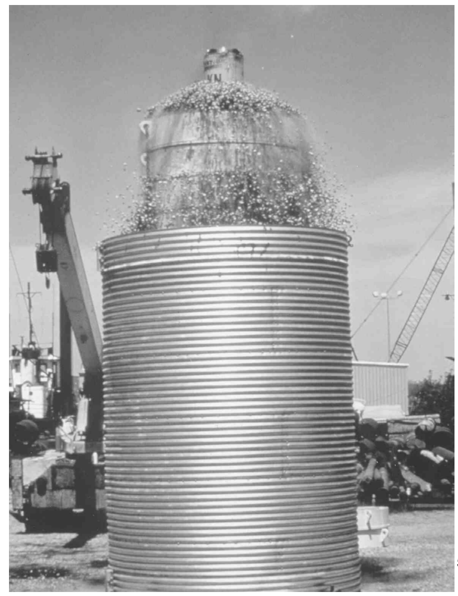
14-14

The conventional method can also be used to conduct uplift, or “pullout,” tests using a configuration similar to that shown for the axial load test. Conventional pullout tests are often less expensive than conventional compression tests because the reaction beam can often be placed on mats or cribbing, eliminating the need for expensive reaction shafts.

If production shafts are to be subjected to substantial uplift loading during their design lives (e.g., because of overturning moments applied to the structure through seismic events or extreme winds, foundations at the anchorage end of permanent cantilevers), it is appropriate to perform uplift tests. An arrangement for the performance of a conventional uplift test of a drilled shaft is shown above. The key feature of the arrangement is that some of the longitudinal rebars, that are embedded full length in the test shaft, extend upward to a point well above the head of the test shaft. It is helpful if these extended rebars are made of high-strength steel.

Statnamic Load Test





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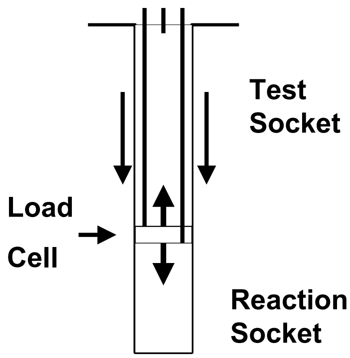
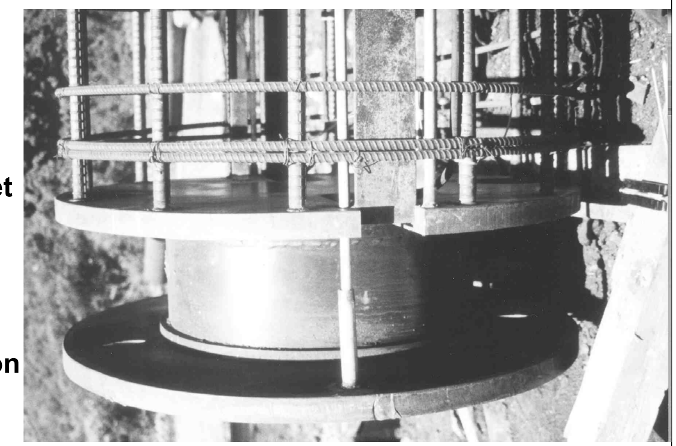
An alternate way of testing drilled shafts is the Statnamic® test method. An advantage of this method relative to the Osterberg Cell method is that it can be used to test shafts that are not initially planned for testing. (In the Osterberg Cell method the cell must be cast into the shaft at the time of construction.) The principle of operation is shown on the left. Heavy masses on top of the shaft are accelerated upward by a propellant. This produces a force against the masses equal to the mass of the accelerated masses time the magnitude of the acceleration and an equal and opposite force on the top of the shaft. The force is active for perhaps half a second (500 milli sec), with a rise time of 100 - 200 milli sec. This rise time is long enough to produce a stress wave in the shaft that is longer than the shaft itself (if the shaft is, say 20 m long or shorter), in which case the shaft can be treated for data reduction purposes as a rigid body. On the right is a photo of a Statnamic test being performed. Gravel, contained within a steel sheath, is usually placed around the masses in order to cushion their impact when they fall back onto the top of the shaft. Newer support devices have recently been deployed with guides that contain the reaction masses laterally as they move upward and “catch” them as the fall back to the head of the shaft. This does away with the need for gravel and speeds up the testing process. Statnamic tests can be run to almost any magnitude of load from a few tons to 3600 tons (1999), by changing components in the system.

Statnamic Load Test

Pictured above are photographs from a large Statnamic test taken before, during and after the propellant was exploded.

Osterberg Load Cell





14-17

This slide is given to indicate the principle of the operation of the Osterberg Cell. One 3000-ton cell (photo on right) is used here to test a socket in soft rock. The socket diameter is 60 inches, so the 2-inch steel plates on either side of the Osterberg Cell are 59 inches in diameter. In this case the objective of the test was to find the ultimate side shearing resistance in the soft rock. Calculations showed that if the base were used as a reaction, base failure would occur first, so a reaction socket was constructed, whose combined base and side capacity was well above the estimated capacity of the upper, or test, socket. The Osterberg Cell rested on top of the reaction socket. In this way, 3000 tons of side shear could be put on the test socket. It would be intended that the upper (test) socket would fail before the 3000-ton limit is reached, so that the exact side shearing resistance is known. If the reaction socket is instrumented, considerable information could be gained about lower limits of side and base resistance in the reaction sockets, as well. Other configurations can be used to test end bearing only or to test both end bearing and side resistance using multiple level of cells. If higher loads are needed, more than one cell can be placed at one level, as long as the shaft diameter can accommodate the 34-inch cell diameter.

Lateral Osterberg Cell Test

4-18

This 3000-ton O-Cell was placed vertically in a rock socket four feet in diameter. The two vertical halves of the socket were pushed apart with the O-Cell while the movement between the two halves was measured by means of sacrificial LVDT's.

Lateral load tests have also been successfully performed using Statnamic devices placed on horizontal sleds. Such tests are probably more appropriate for simulating impact loading than are either conventional or Osterberg Cell tests. Large inertial mass vibrators have been used on occasion to simulate seismic loading.

INTEGRITY TESTS

- **Sonic Echo / Impulse-response**
- **Coring**
- **Cross-hole Acoustic ("CSL")**
- **Visual Observation**
- **Gamma-Gamma**

14-19

INTEGRITY TESTS

“Anomalies.” unusual patterns: voids or soft spots in the concrete.

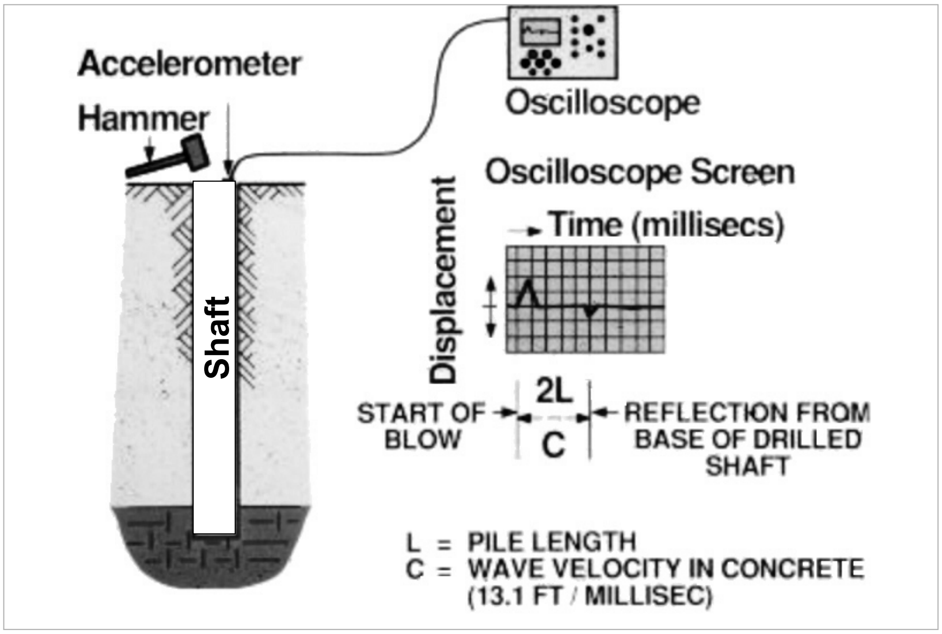
Anomalies are probably structural defects if they correlate to some potentially damaging occurrence during construction recorded by the Inspector.

14-20

This slide succinctly explains the difference between an anomaly and a defect. Various post-construction structural integrity tests can give “false positives” or divergences of a sonic or ionizing radiation record from that which would be expected from a structurally perfect drilled shaft. This does not always mean that the shaft is defective. We merely use the term “anomaly” to denote any deviation from the expected in the integrity test record. If that deviation corresponds to a potentially damaging occurrence during construction (such as the elevation of the base of the casing at the time when the column of concrete inside a casing is lifted as the casing is pulled), then it is prudent to assume that the anomaly is a structural defect that requires further attention.

Note that good inspection records are key to the interpretation of integrity tests.

Sonic Echo Test



This is a schematic of a pulse-echo (sonic-echo) test. The principle is obvious from the sketch. Advantages of the test are that it can be done on virtually any shaft without prior planning (no access tubes need be placed in the shaft) and is quick and inexpensive. Disadvantages are that it is prone to showing false positives and to missing fairly large voids or inclusions in the concrete. It is essentially 100 per cent accurate only if the void or inclusion covers about half of the cross-sectional area of the shaft and is reasonably thick (say 0.5 m or thicker) and the test is performed correctly. This test is not usually effective in locating deep defects (depth > 60 feet or 20 m) and cannot detect contact problems between the concrete and the soil or rock. The apparatus to perform this test is available commercially, and numerous consultants provide this service. However, consultant service varies widely in quality. False positives in this method come from changes in cross-section that are not associated with an anomaly, from changes in concrete modulus (such as at the interface between concrete placed from two different trucks), from changes in the stiffness of the soil or rock surrounding the shaft, which also dissipate sonic energy, and from testing technique errors such as setting the sensor on weak or powdery concrete.

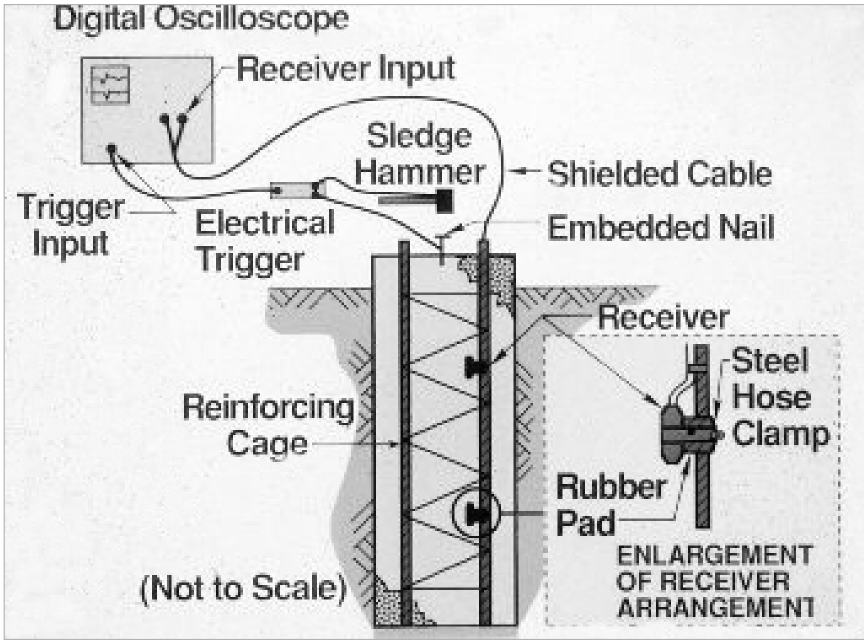
This test can be simulated by conducting a wave equation analysis on an imaginary cylindrical rod of the same purported dimensions as the shaft being tested. Voids of various sizes and shapes can be introduced into the wave-equation computer model until the signal from the pulse-echo test matches the signal from the wave-equation simulation. In this way, the location and size of defects can be inferred.

Performing a Sonic Echo Test

14-22

This is a photo of a sonic-echo test being performed. Note that the technician has embedded a nail in the top of the shaft's concrete so as to provide a sharp sonic wave. This will help find small defects near the top of the shaft. To search for deeper defects, a larger hammer with a hard cushion might be used to produce a sonic compression wave of longer length that will propagate deeper (but with less resolution) that the sharp wave.

Sonic Echo Test with Internal Instrumentation



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Pulse-echo tests can also be performed with internal instrumentation, as illustrated here. The advantage to this variation is that defects can be interpreted more clearly to a greater depth than with only external instruments. The disadvantage is that the instruments must be placed in the shaft before construction, so that the method cannot be used arbitrarily to test shafts suspected of having defects that have not been instrumented before constructing them.

The record on the right shows a shaft that is free of defects. The wave is clearly reflecting off the base of the shaft.

Very large defect found
by Sonic Echo test.
Probably due to dirty hole.

14-24

from FHWA Publication IF-99-025

This is a photograph of a defect on a highway bridge after contaminated concrete had been chipped away. A severe defect of this size can be detected with almost certainty by the sonic echo method.

Coring

Core Barrel Bit

14-25

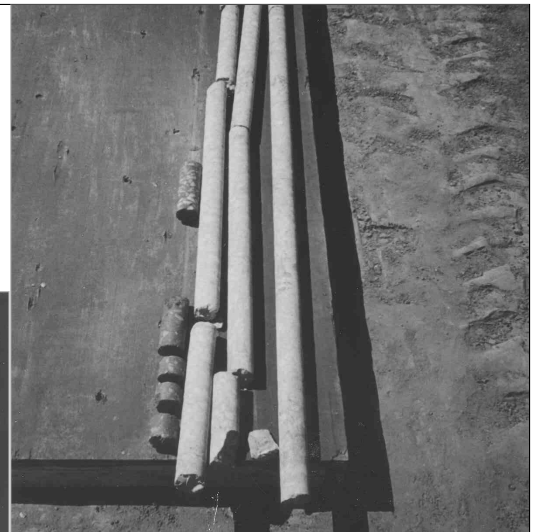
Coring of drilled shafts can be used as an independent integrity test method, or it can be used to attempt to confirm the presence of defects that appear as anomalies on pulse-echo records.

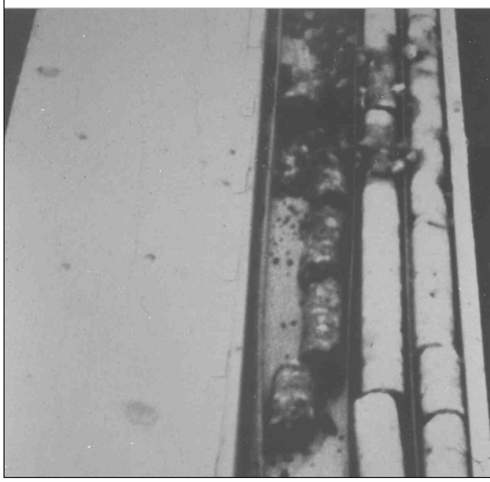
Coring is not full-proof, however, as cores can bypass serious defects. So, coring is a way of potentially confirming that the shaft is defective but not that it is not defective.

Very careful coring is sometimes an effective way to investigate whether there is a soft base in the drilled shaft.

Coring Is Not Always Definitive in Ruling Out Defects —

Defects Can Be Missed by the Coring Tool





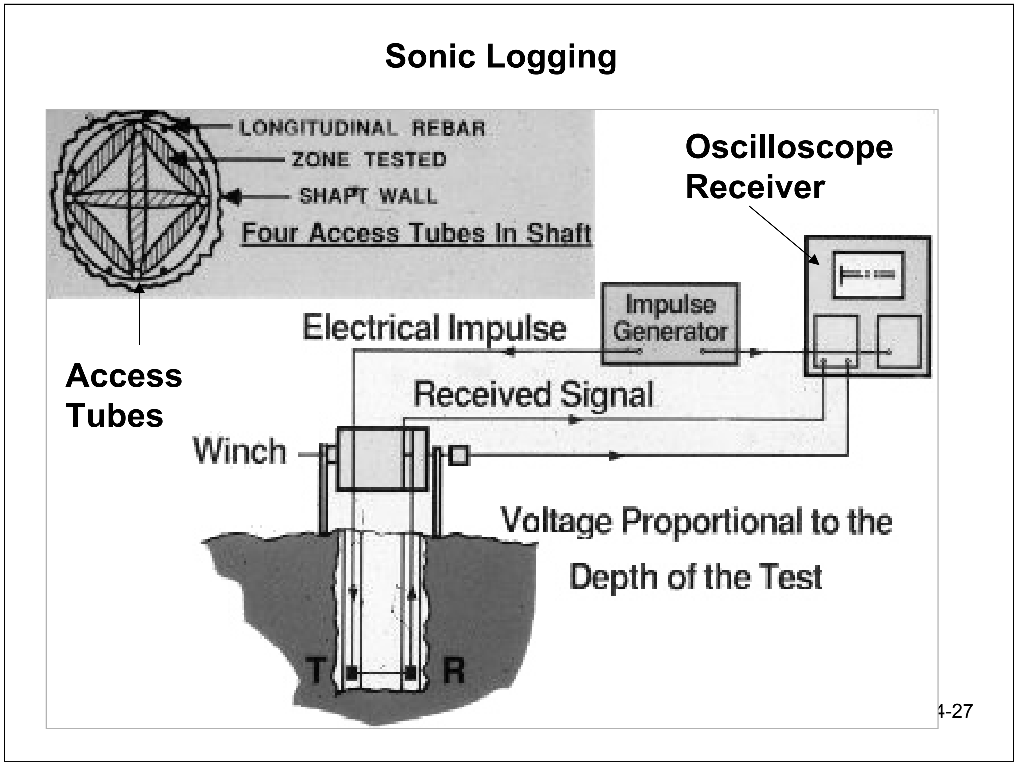
Acceptable

Not Good

14-26

These photos show the cores from two drilled shafts. The top core was from a shaft that was apparently acceptable (a companion core in the same shaft also showed no signs of defects, so the state DOT accepted the shaft). The lower core was taken from a shaft that was constructed on a batter, with temporary casing, and the temporary casing was withdrawn as the concrete was beginning to set, compromising the quality of the concrete. The Contractor was required to excavate about 15 feet (5 m) of soil from around the shaft and to reform the top of the shaft. So, in these cases coring alone was deemed successful.

A disadvantage of coring relative to pulse-echo testing is that it consumes more time and requires the core hole to be carefully filled with grout. It may also be difficult to position a coring rig atop the shaft, whereas minimal equipment is needed atop the shaft in a pulse-echo test.

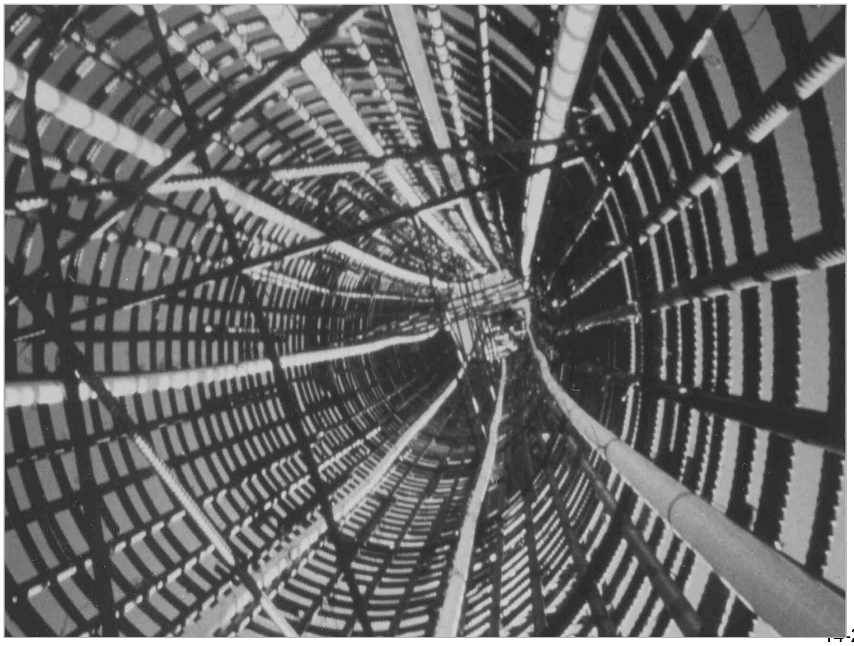


A primary use of access tubes is in the performance of cross-hole acoustic tests (usually ultrasonic in air but sonic in concrete), sometimes called cross-hole sonic log tests or CSL tests. Several access tubes are placed regularly around the circumference of the cage. One per foot of shaft diameter is a good rule of thumb. “Shots” are made from a source that generates acoustic energy to an energy receiver in another tube at the same elevation, as depicted here. Both the time of travel from the source tube to the receiver tube and the amount of energy transferred between tubes are indicators of the presence of either sound concrete or defective concrete. Good coverage of the interior of the cage can usually be achieved, as shown in the upper left side. However, little information on concrete outside the cage can be obtained.

Several variations on this method are practiced by highly skilled specialists, involving placing source and receiver at different elevations to develop a three-dimensional profile of the interior of the shaft, in a process referred to as tomography.

This method can be performed fairly quickly and is often more definitive than the pulse-echo method or its derivatives. With this method it is a good idea to use tubes made of a material that expands and contracts thermally with concrete. Schedule 40 steel tubes fit this requirement and are recommended. PVC tubes do not and may debond from the concrete, although if a test is performed soon after the concrete sets (usually within 7 days), the bonding may remain strong enough for the requisite passage of the sonic waves. In order to help maintain bond between the tubes and concrete and to couple the transmitter and receiver to the concrete, the tubes should be filled with water soon after the concrete is placed.

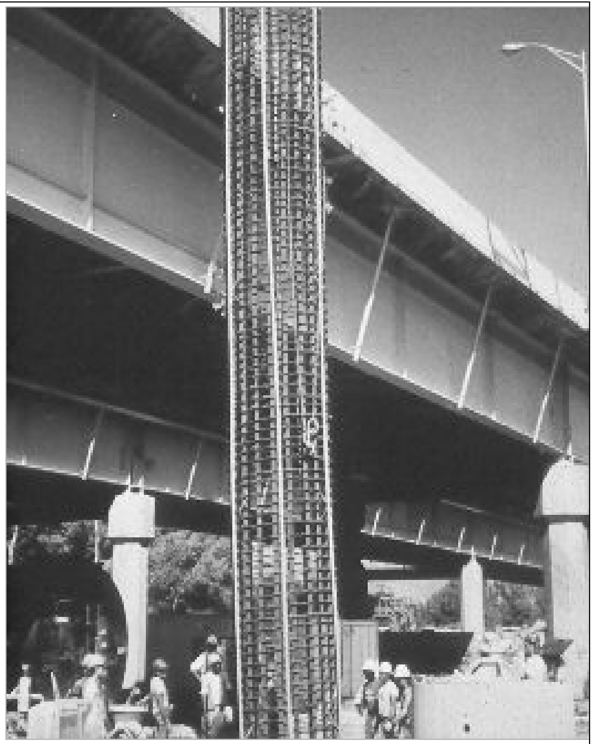
Access Tubes for Down-Shaft Tests



14-28

Access tubes need to be cast into the concrete at the time of construction, which is the major disadvantage of tests employing access tubes. Different tests require different types of tubes (e. g., PVC for gamma-gamma versus Schedule 40 steel for CSL). Some tests require that the tubes are filled with water, and some don't.

Access Tubes Outside the Reinforcing Cage

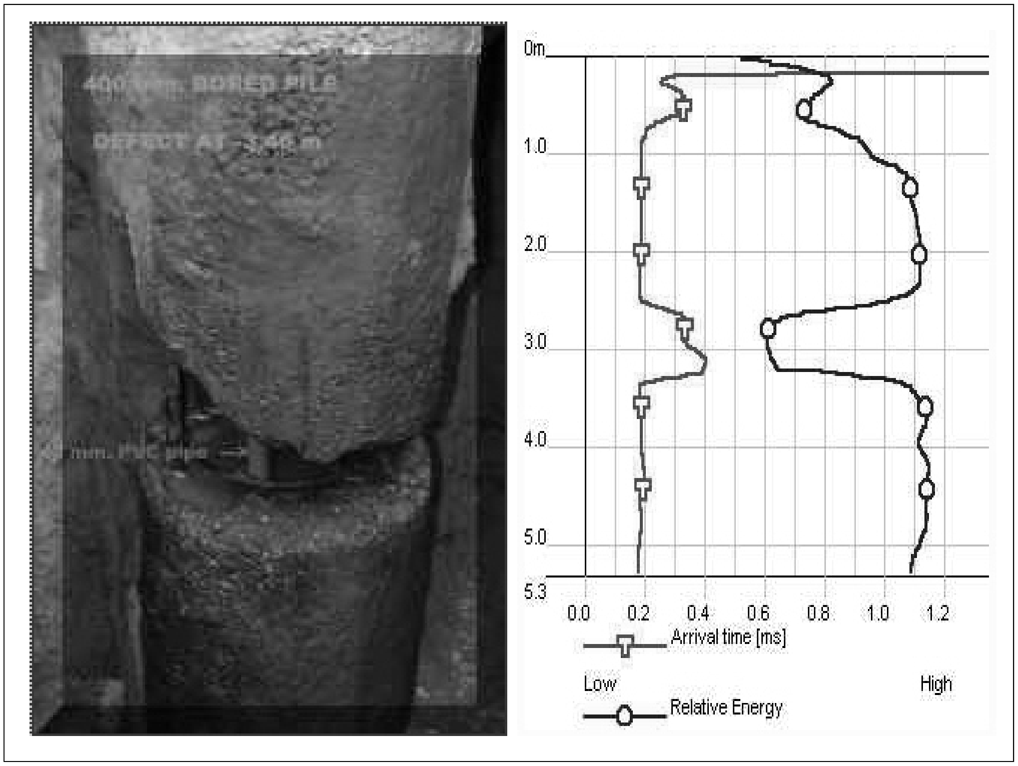


Access tubes are normally affixed to the cage on the inside of the cage. Sometimes, access tubes are placed on the outside of the cage, as shown here. It is more difficult to protect tubes in this position from damage during placement of the cage than if the tubes are on the inside of the cage. The reason for using external access tubes is to allow the concrete outside the cage to be tested. This concrete is the most prone to being defective, but from an ultimate load-carrying perspective, it is probably less important than the core concrete inside the cage.

Source and Receiver Tools for CSL Test

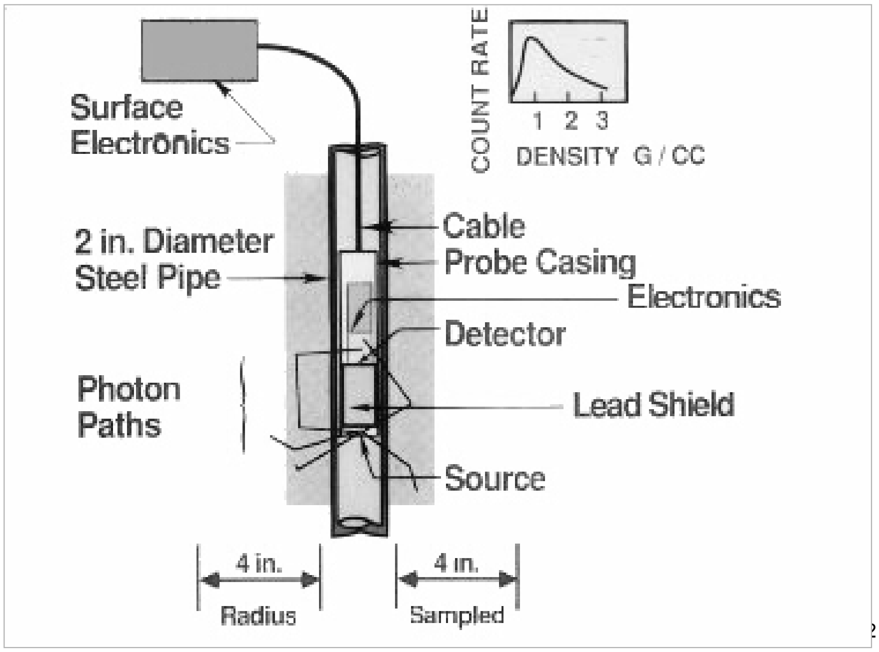
14-30

These are the source and receiver devices that are passed down the access tubes in a CSL test. Some provision needs to be contained in the specification item on NDT that the access tubes will be able to pass these sensors at the time the tests are to be performed. Otherwise, the Contractor should ream out the tubes with an appropriate tool. Several models are available that have different diameters, so the designer should have some idea of which consultant will be performing the CSL tests so he or she can specify the sizes of the access tubes. Alternatively, the designer can let the Contractor select the sizes of the access tubes with the designer's approval.


0m
1.0
2.0
3.0
4.0
5.0
5.3
0.0 0.2 0.4 0.6 0.8 1.0 1.2
Arrival time [ms]
Low
High
Relative Energy


40 mm. PVC pipe --->

Principle of the Gamma-Gamma Test



Another successful down-tube integrity test is the gamma-gamma, or backscatter gamma test, illustrated here. The device is a nuclear density meter that must be calibrated frequently. It measures density in the concrete to about 100 mm (4 inches) from the edge of the tube. Newer devices can reportedly measure density to about twelve inches from the tube, but that characteristic is of little use if the tube is less than twelve inches from the edge of the shaft. A disadvantage of the device is that it does not “shoot” across the shaft as does a CSL device, so it does not test the entire cross-section, and it is sensitive to being placed too close to a longitudinal rebar. Otherwise, it is a very definitive test.

Defect that Produced Anomalous Gamma-Gamma Readings

Probably from dirty hole

PVC Access tube

14-33

Performing a Gamma-Gamma Test

34

This is a gamma-gamma tool being lowered into an access tube on a test shaft.

A Good Shaft

14-35

While the previous slides may suggest that defects in drilled shafts are numerous, a defective shaft should be the exception rather than the rule. If the contractor follows good practice, as described in the Reference Manual, and the DOT writes clear and fair specifications (as per the guide specification in Chapter 15 of the Reference Manual), drilled shafts should look like this. This is a 70-foot- long shaft constructed under mineral drilling slurry, load tested to geotechnical failure and then exhumed for observation. The shaft was almost perfectly cylindrical, and no concrete contamination could be observed.

<u>LEARNING OBJECTIVE # 2</u>
Identify and describe various integrity and load tests

Access tubes in the shaft are required for which down-hole Direct Transmission tests?

What is the name of an Surface Reflection integrity test performed with a hammer an oscilloscope?

14-36

LEARNING OBJECTIVE # 2
Identify and describe various integrity and load tests

What are the two categories of post-installation tests?

What are the three different ways of applying load to a test shaft?

14-37

SAMPLE DRILLED SHAFT INSPECTION CHECKLIST

Post Installation

56. If shaft is constructed in open water, is the shaft protected for seven days or until the concrete strength reaches a minimum of 2,500 psi (17MPa) in accordance with xxx.36, Casings? 56 56
57. Is all casing removed to the proper elevation in accordance with xxx.36.2, Permanent Casing? 57 57
58. Has the Contractor complied with xxx. 64, Nondestructive Evaluation, if required? 58 58
59. Is the shaft within the applicable construction tolerances (xxx. 41, Construction Tolerances)? 59 59
60. Has the Drilled Shaft Log been completed? 60 60
61. Have you documented the Pay Items? 61 61

14-38

SAMPLE DRILLED SHAFT INSPECTOR'S CHECKLIST

The following is a general checklist to follow when constructing a Drilled Shaft. The answer to each of these should be "yes" unless plans, specifications or specific approval has been given otherwise ***CONSULT WITH RESPONSIBLE ENGINEER FOR YOUR SPECIFIC PROJECT RESPONSIBILITIES.***

	Yes	No	NA
Reinforcing Cage			
41. Is the rebar the correct size and configured in accordance with the project plans?	41	41	
42. Is the rebar properly tied in accordance with xxx.50, Reinforcing Steel Cage Construction & Placement?	42	42	
43. Does the Contractor have the proper spacers for the steel cage in accordance with xxx.50, Reinforcing Steel Cage Construction & Placement?	43	43	
44. Does the Contractor have the proper amount of spacers for the steel cage in accordance with xxx.50, Reinforcing Steel Cage Construction & Placement?	44	44	
45. If the cage is spliced, was it done in accordance with the contract documents?	45	45	
46. Is the steel cage secured from settling and from floating (during concrete placement cages sometimes rise with the concrete) (xxx.50, Reinforcing Steel Cage Construction & Placement)?	46	46	
47. Is the top of the steel cage at the proper elevation in accordance with xxx.41, Construction Tolerances?	47	47	
Concreting Operations			
48. Prior to concrete placement, has the slurry (both manufactured & natural) been tested in accordance with xxx.38, Slurry?	48	48	
49. If required, was casing removed per xxx.36.1, Temporary Casings?	49	49	
50. Was the discharge end of the tremie maintained in the concrete mass with proper concrete head above it xxx.61, Tremies)?	50	50	
51. If free-fall placement (dry shaft only), was concrete placed in accordance with xxx.60, Concrete Placement?	51	51	
52. Did the placement occur within the time limit specified (xxx.60, Concrete Placement)?	52	52	
53. Are you filling out the concrete placement and volume forms?	53	53	
54. When placing concrete, did the contractor overflow the shaft until good concrete flowed (xxx.60, Concrete Placement)?	54	54	
55. Were concrete acceptance tests performed as required?	55	55	
Post Installation			
56. If shaft is constructed in open water, is the shaft protected for seven days or until the concrete strength reaches a minimum of 2,500 psi (17MPa) in accordance with xxx.36, Casings?	56	56	
57. Is all casing removed to the proper elevation in accordance with xxx.36.2, Permanent Casing?	57	57	
58. Has the Contractor complied with xxx. 64, Nondestructive Evaluation, if required?	58	58	
59. Is the shaft within the applicable construction tolerances (xxx. 41, Construction Tolerances)?	59	59	
60. Has the Drilled Shaft Log been completed?	60	60	
61. Have you documented the Pay Items?	61	61	
Notes/Comments			

56. If shaft is constructed in open water, is the shaft protected for seven days or until the concrete strength reaches a minimum of 2,500 psi (17MPa) in accordance with xxx.36, Casings?

xxx. 36 CASINGS

- **Shaft concrete is not exposed to salt or moving water for 7 days**
- **Must reach 2500 psi (17.2 MPa) compressive strength**

14-40

<u>FHWA Publication IF-99-025</u>

xxx. 365 CASINGS

…Casings can be removed when the concrete has attained sufficient strength provided: curing of the concrete is continued for a 72-hour period; the shaft concrete is not exposed to salt water or moving water for 7 days; and the concrete reaches a compressive strength of at least 2500 psi (17.2 MPa), as determined from concrete cylinder breaks.

57. Is all casing removed to the proper elevation in accordance with xxx.36.2, Permanent Casing?

xxx. 36.2 PERMANENT CASING

- **Permanent casing cutoff at the prescribed elevation**

14-41

FHWA Publication IF-99-025

xxx. 36.2 PERMANENT CASING

…After installation is complete, the permanent casing shall be cut off at the prescribed elevation and the shaft completed by installing necessary reinforcing steel and concrete in the casing.

58. Has the Contractor complied with xxx. 64, Nondestructive Evaluation, if required?

xxx. 64 NON DESTRUCTIVE EVALUATION

- **The Contractor is responsible for performing tests and submitting results**

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<u>FHWA Publication IF-99-025</u>

xxx. 64 NON DESTRUCTIVE EVALUATION

…When called for in the contract documents, specific completed drilled shafts, the number and/or location of which are specified in the contract documents, shall be subjected to nondestructive tests to evaluate their structural integrity. Such tests may include (a) downhole tests conducted in access tubes, including crosshole acoustic tests and backscatter gamma ray (gamma-gamma) tests, or (b) sonic echo tests. The type of test to be used, if any, is specified in the contract documents The Contractor shall be responsible for performing and submitting reports of such tests to the Engineer in a timely manner. …..

58. Has the Contractor complied with xxx. 64, Nondestructive Evaluation, if required?

xxx. 64 NON DESTRUCTIVE EVALUATION

- **Concrete to have cured minimum 24 hours**
- **Must be registered Professional Engineer responsible for test and report**
- **Report must be submitted within 3 days of test**

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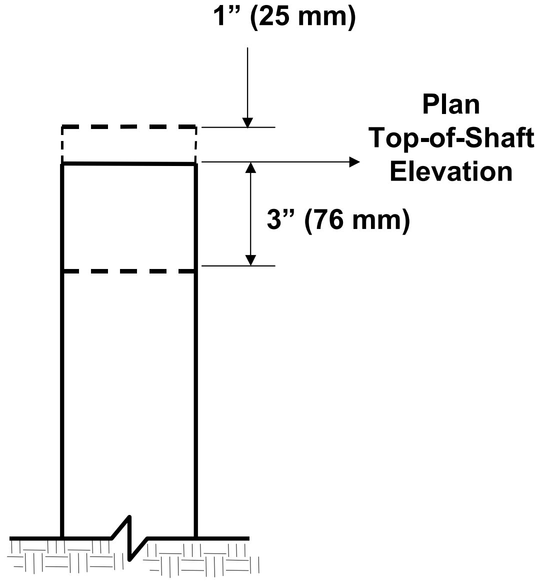
FHWA Publication IF-99-025

xxx. 64 NON DESTRUCTIVE EVALUATION

….All testing shall be conducted after the concrete has cured for at least 24 hours. The Contractor shall employ a registered professional engineer who has been qualified by the State to perform, evaluate and report the tests. The report on the tests on any given shaft must be submitted to the Engineer within 3 working days of the performance of the tests on that shaft. The Engineer will evaluate and analyze the results and provide to the Contractor a response regarding the acceptability of the shaft that was tested within 3 working days of receipt of the test report.

59. Is the shaft within the applicable construction tolerances (xxx. 41, Construction Tolerances)?



14-44

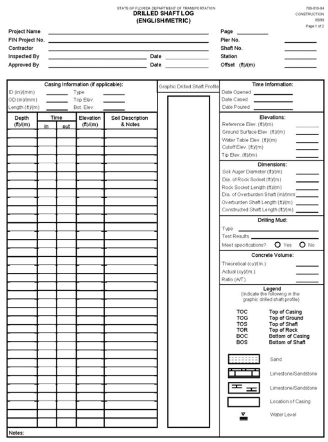
FHWA Publication IF-99-025

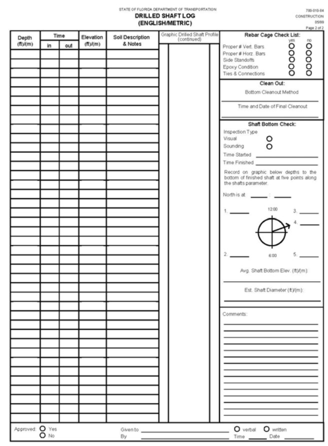
xxx. 41 TOLERANCES

….. The top elevation of the shaft shall have a tolerance of plus 1 inch (25 mm) or minus 3 inches (76 mm) from the plan top-of-shaft elevation...

60. Has the Drilled Shaft Log been completed?

The Drilled Shaft Log compiles all of the data recorded during the installation into one concise form for records.





14-45

SAMPLE

DRILLED SHAFT LOG
(ENGLISH/METRIC)

CONSTRUCTION
05/99
Page 1 of 2

Project Name ______________________ Page ________
FIN Project No. ______________________ Pier No. ________
Contractor ______________________ Shaft No. ________
Inspected By ______________ Date ________ Station ________
Approved By ______________ Date ________ Offset (ft)/(m) ________

Casing Information (if applicable):

ID (in)/(mm) ________ Type ________
OD (in)/(mm) ________ Top Elev. ________
Length (ft)/(m) ________ Bot. Elev. ________

Depth (ft)/(m)	Time in	Time out	Elevation (ft)/(m)	Soil Description & Notes

Graphic Drilled Shaft Profile

Time Information:

Date Opened ________
Date Cased ________
Date Poured ________

Elevations:

Reference Elev. (ft)/(m) ________
Ground Surface Elev. (ft)/(m) ________
Water Table Elev. (ft)/(m) ________
Cutoff Elev. (ft)/(m) ________
Tip Elev. (ft)/(m) ________

Dimensions:

Soil Auger Diameter (ft)/(m) ________
Dia. of Rock Socket (ft)/(m) ________
Rock Socket Length (ft)/(m) ________
Dia. of Overburden Shaft (in)/(mm) ________
Overburden Shaft Length (ft)/(m) ________
Constructed Shaft Length (ft)/(m) ________

Drilling Mud:

Type ________
Test Results ________
Meet specifications? ○ Yes ○ No

Concrete Volume:

Theoretical (cy)/(m.) ________
Actual (cy)/(m.) ________
Ratio (A/T) ________

Legend
(Indicate the following in the graphic drilled shaft profile)

TOC	Top of Casing
TOG	Top of Ground
TOS	Top of Shaft
TOR	Top of Rock
BOC	Bottom of Casing
BOS	Bottom of Shaft

Sand
Limestone/Sandstone
Limestone/Sandstone
Location of Casing
Water Level

Notes:

CONSTRUCTION
05/99

SAMPLE
DRILLED SHAFT LOG
(ENGLISH/METRIC)

Depth (ft)/(m)	Time		Elevation (ft)/(m)	Soil Description & Notes	Graphic Drilled Shaft Profile (continued)
	in	out			

Rebar Cage Check List:

	yes	no
Proper # Vert. Bars	O	O
Proper # Horz. Bars	O	O
Side Standoffs	O	O
Epoxy Condition	O	O
Ties & Connections	O	O

Clean Out:

Bottom Cleanout Method

____

Time and Date of Final Cleanout

____

Shaft Bottom Check:

Inspection Type

Visual O

Sounding O

Time Started ______________

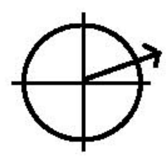
Time Finished ______________

Record on graphic below depths to the bottom of finished shaft at five points along the shafts parameter.

North is at _____ : _____

1. _____ 12:00 3. _____

4. _____



2. _____ 6:00 5. _____

Avg. Shaft Bottom Elev. (ft)/(m):

____

Est. Shaft Diameter (ft)/(m):

____

Comments:

____

Approved: O Yes O No

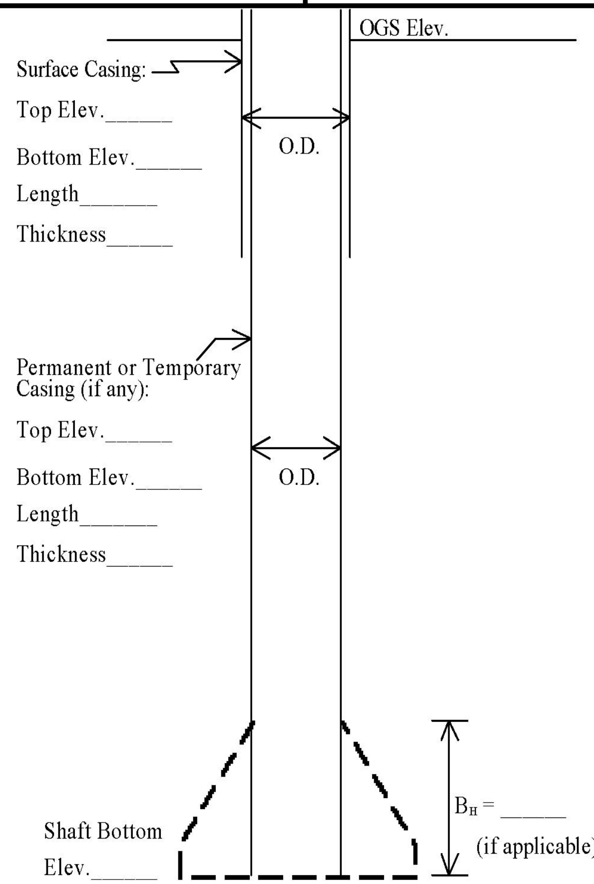
Given to ______________________ O verbal O written

By ______________________ Time _______ Date _______

	GEOTECHNICAL ENGINEERING BUREAU **DRILLED SHAFT IN SOIL - FIELD RECORD**
	STRUCTURE
	SHAFT NUMBER DATE

PROJECT STAMP

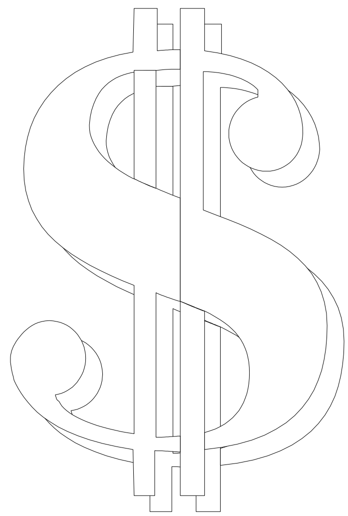
Date Excavation Started Finished		
Date Bottom Observed		
Date Concrete Placed		
	DESIGN	AS-BUILT
Station		
Offset		
Top Elevation		
Bottom Elevation		
Shaft Diameter		
Shaft Length		
Bell Diameter (if appl.)		
Bell Height B_H (if appl.)		
Plumbness		
Design Capacity		
Observed Groundwater Elevation		
Remarks:		



SHAFT IN SOIL

Date	Time	Depth	Soil or Rock Description	Tool	Observations

61. Have you documented the pay items?



All Pay Items should have been documented.

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To the Contractor, this is perhaps the most important document to be completed. Generally, these types of forms are what the Contractor is paid from.

Most contracts reimburse the Contractor per foot or meter of something, per each for some items and lump sum for a few things. These need to be recorded correctly. Depending upon their bid price, the difference between 30 feet or 60 feet can represent a lot of dollars. Conversely, if the pay item should be 30 feet, not 60, the DOT doesn't want to pay 60 feet.

The Contractor is entitled to be paid for what was furnished, installed and accepted.

Remember, Document, Document.

PAY ITEMS

PAY ITEMS	Unit: Length in feet/meters	Unit: Bell included	Unit: Bell, each- Lump Sum	Unit: Hours	Unit: Each or Lump Sum	xxx.71 "Measurement" Comments	xxx. 72 "Payment" Comments
Furnishing DS Drilling Equipment					✓	All equip. on-site, assembled, ready to drill ; shafts completed	60%; 40%
Drilled Shafts	✓					Top of shaft to the final bottom of shaft	Contract unit price
Standard Excavation	✓		✓			Top of shaft to top of bell or bottom of shaft, if no bell	Contract unit price
Special Excavation	✓		✓			Top of shaft to top of bell or bottom of shaft, if no bell	Contract unit price
Unclassified Shaft Excavation	✓		✓			Top of shaft to top of bell or bottom of shaft, if no bell	Contract unit price
Unclassified Extra Depth Excavation	✓					Base elev. in plans to final authorized & accepted elev.	150 % of Contract unit price
Obstructions				✓		Must be designated obstruction by Engineer	Contract unit price
Trial Shaft	✓	✓				Existing ground surface to bottom of shaft , including bell	Contract unit price
Exploration (Shaft Excavation)	✓					Bottom of shaft to the bottom of exploration hole	Contract unit price
Load Tests					✓	Number, per plans, conducted	Contract unit price
Permanent Casing	✓					Lowest of top of shaft or casing to bottom of casing	Contract unit price
Instrumentation & Data Collection					✓		Contract unit price
Protection of Existing Structures					✓	Items not included in plans and ordered by Eng., extra work	Contract unit price
Access Tubes	✓						Contract unit price
NDE Tests					✓	Includes mob, testing, analysis, and reporting	Contract unit price

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Detailed descriptions and discussions on the Pay Items can be found in the FHWA Guide Specifications, which are appended.

xxx.71 METHOD OF MEASUREMENT

xxx.72 BASIS OF PAYMENT

PAY ITEMS	Unit: Length in feet/meters	Unit: Bell included	Unit: Bell, each - Lump Sum	Unit: Hours	Unit: Each or Lump Sum	xxx.71 "Measurement" Comments	xxx. 72 "Payment" Comments
Furnishing DS Drilling Equipment					✔	All equip. on-site, assembled, ready to drill ; shafts completed	60%; 40%
Drilled Shafts	✔					Top of shaft to the final bottom of shaft	Contract unit price
Standard Excavation	✔		✔			Top of shaft to top of bell or bottom of shaft, if no bell	Contract unit price
Special Excavation	✔		✔			Top of shaft to top of bell or bottom of shaft, if no bell	Contract unit price
Unclassified Shaft Excavation	✔		✔			Top of shaft to top of bell or bottom of shaft, if no bell	Contract unit price
Unclassified Extra Depth Excavation	✔					Base elev. in plans to final authorized & accepted elev.	150 % of Contract unit price
Obstructions				✔		Must be designated obstruction by Engineer	Contract unit price
Trial Shaft	✔	✔				Existing ground surface to bottom of shaft , including bell	Contract unit price
Exploration (Shaft Excavation)	✔					Bottom of shaft to the bottom of exploration hole	Contract unit price
Load Tests					✔	Number, per plans, conducted	Contract unit price
Permanent Casing	✔					Lowest of top of shaft or casing to bottom of casing	Contract unit price
Instrumentation & Data Collection					✔		Contract unit price
Protection of Existing Structures					✔	Items not included in plans and ordered by Eng., extra work	Contract unit price
Access Tubes	✔						Contract unit price
NDE Tests					✔	Includes mob, testing, analysis, and reporting	Contract unit price

LEARNING OBJECTIVES

- **Describe how to verify Checklist Questions 56-61**
- **Identify and describe various Integrity and Load Tests**
- **Explain how to assess and verify the Contractor's compliance with specifications for casing removal, elevation requirements and construction tolerances**
- **Describe the Drilled Shaft Pay Items**

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ANY QUESTIONS?

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NOTES